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(54) Stretched, fluid jet entangled non-woven laminate

(57) A composite non-woven fabric having a high dimensional stability is prepared by cross-stretching by 20 to 200% a starting non-woven fabric obtained by a fiber entanglement treatment of a staple fiber web by fluid jets to form a substrate, then introducing short fibers onto this cross-stretched substrate and filling said cross-stretched substrate with said short fibers by further fiber entanglement treatment by more closely spaced fluid jets. The staple fibre web may be a corded web of polyester, polyolefin, acrylic or nylon fibres. The short fibres may be those or razor or wood pulp and be supplied as a sheet or a slurry. The fabric is suitable as cloth for disposable medical garments.

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FIG.1

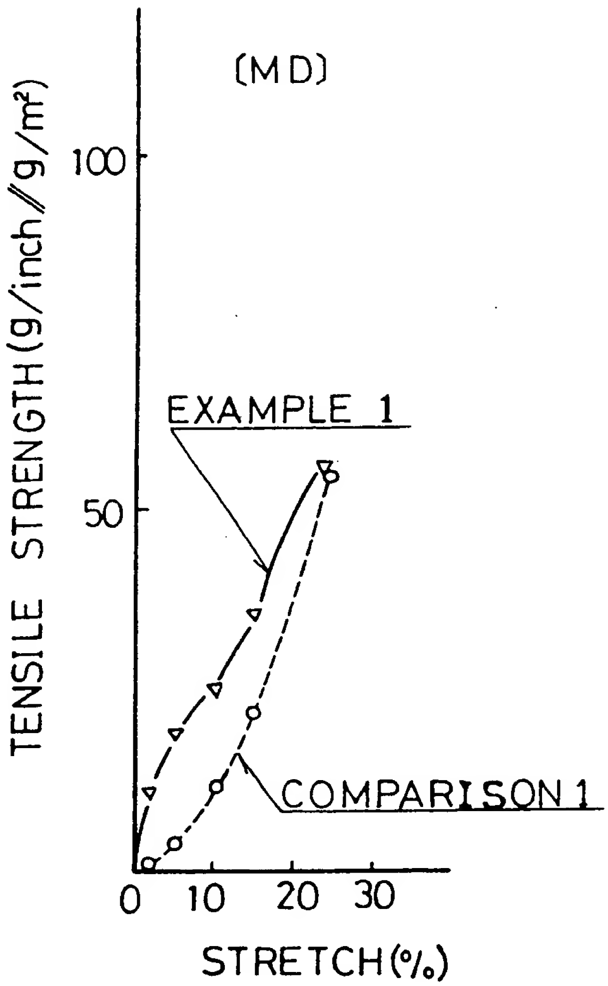
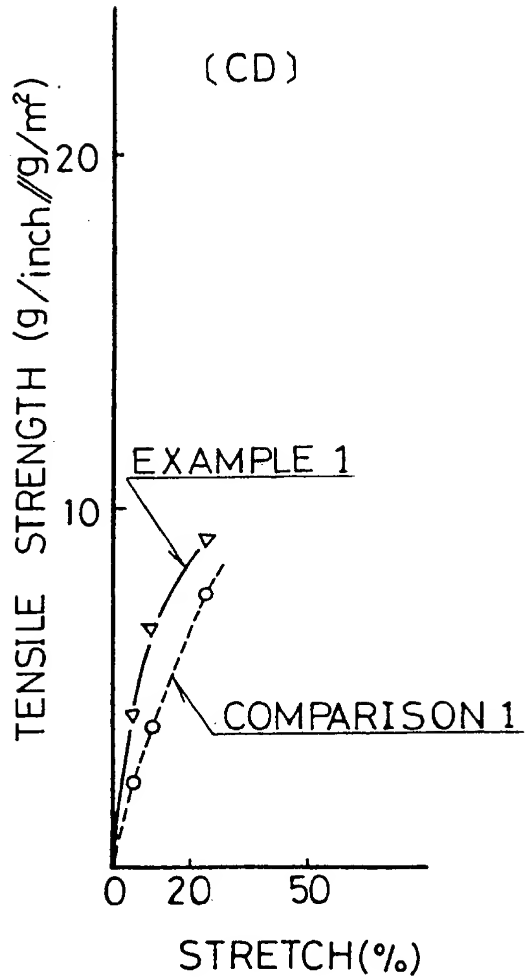


FIG.2



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COMPOSITE NONWOVEN FABRIC AND PROCESS FOR PREPARING SUCH NONWOVEN FABRIC

The present invention relates to a composite nonwoven fabric having high dimensional stability and a process for preparing such nonwoven fabric.

Conventional fiber-entangled nonwoven fabrics prepared by a water jet treatment of a web composed of staple fibers, i.e., spunlaced fabrics, has been disadvantageous in that there is a significant difference between warp and weft tensile strengths and this drawback limits its application. To overcome this problem, there has already been a method proposed for improvement of such differential tensile strength, according to which, after a cross-stretching treatment, the resultant cross-stretched web is fixed by subjecting said web again to the water jets, or by use of a suitable binder or by a heat treatment causing fibers to be welded together, as disclosed, for example, in the Japanese Patent Application Disclosure Gazette No. 49-42970.

However, use of a binder and fixation through fiber welding have been found to deteriorate a drape property and feeling of the fiber-entangled nonwoven fabrics obtained through the water jet treatment.

Fixation of a nonwoven fabric through the fiber

entanglement treatment by subjecting the web to the water jet treatment again after the cross-stretching, on the other hand, would certainly improve the cross direction/machine direction strength ratio of the nonwoven fabric through the fiber entanglement treatment only by the primary water jets, but the ratio of the initial tensile strengths in both directions contributing to the desired dimensional stability of the nonwoven fabric could not be adequately improved by this method. Such problem appears, for example, as a phenomenon that a machine direction tension easily causes a cross direction dimensional change(shrink) and a cross direction tension easily causes a machine direction dimensional change(shrink).

A principal object of the present invention is to provide, in view of the above-mentioned drawback of the prior art, a composite nonwoven fabric being excellent in its drape property and dimensional stability.

Said object is, in accordance with the present invention, by a composite nonwoven fabric comprising a nonwoven fabric substrate composed of first staple fibers and second short fibers entangled on and in said nonwoven fabric substrate under action of fluid, characterized by that said substrate comprising a fiber-entangled nonwoven

fabric stretched in cross direction by approximately 20 to 200% and that traces of fluid jets are formed on a layer of said fabric comprising predominately the second short fibers, which are more closely spaced from one another than traces of the fluid jets formed on a layer of said fabric comprising predominately the first staple fibers.

The present invention encompasses also a process for preparing said composite nonwoven fabrics comprising: a first step of subjecting a fibrous web comprising first staple fibers to a water jet treatment on a support to form a fiber-entangled nonwoven fabric substrate; a second step of cross-stretching said substrate by approximately 20 to 200%; a third step of introducing second short fibers in the form of a sheet or slurry onto said substrate which has been cross-stretched; a fourth step of subjecting a lamellar material thus comprising said cross-stretched substrate and said second short fibers placed on said substrate to a water jet treatment at a velocity of 40m/sec or higher and under a pressure of at least 10kg/cm^2 onto said second short fibers from above, the water jets being more closely spaced from one another than traces of the water jets which have been formed on said stretched substrate at said second step, on a support comprising a netlike support or a perforated plate having an opening ratio of 2.5 to 50%, so as to entangle said second short fibers among the fibers of said cross-

stretched substrate and thereby to fill interstices of said substrate fibers.

The composite nonwoven fabric constructed according to the present invention has a high dimensional stability since its initial tensile strength is so high to resist any significant stretch and is excellent also in its drape property as well as in its feeling. Therefore, the composite nonwoven fabric of the invention is commonly useful as cloth for disposable sheets and garments, particularly for those which are usually used in medical field of application such as gown, drape, hood and bed sheets used in the surgical operating room.

The invention will be described more in detail by way of example with reference to the accompanying drawings, wherein:

Figs.1 and 2 are graphic diagrams showing correlation of tensile strength and stretch in MD and CD directions of nonwoven fabric respectively in EXAMPLE 1 and COMPARISON 1.

The composite nonwoven fabric of the present invention is prepared through a process comprising steps of a cross-stretching starting nonwoven fabric composed of first staple fibers which have been subjected to a primary

entanglement treatment by water jets, then placing second short fibers on the cross-stretched nonwoven fabric and subjecting this lamellar material to a secondary fiber entanglement treatment by water jets.

A fibrous web such as a card web composed of the first staple fibers is subjected to the fiber entanglement treatment by water jets in a well known manner, for example, as disclosed by U.S. Patent No. 3,508,308 to provide the desired starting nonwoven fabric. This starting nonwoven fabric is cross-stretched by approximately 20 to 200% with respect to its initial width to form composite a nonwoven fabric substrate having its machine direction/cross direction strength ratio improved. Cross-stretching ratio is preferably approximately 20 to 100%. To improve an absolute strength of the substrate, the first staple fiber preferably has a fiber length of 20 to 130mm and a fineness of 0.7 to 6d, which is preferably selected from a group consisting of polyester fiber, acryl fiber, nylon fiber and polyolefine fiber. Particularly it is preferable to use polyester fibers alone. For the cross-stretching treatment, the cross-stretching means of prior art such as a tenter frame may be used. This cross-stretching treatment enhances internal bond of the substrate so as to improve the initial tensile strength. With a consequence, any significant stretch deteriorating the dimensional stability is

suppressed once the substrate has beer cross-stretched by a predetermined ratio.

The second short fibers introduced onto the nonwoven fabric substrate preferably comprise fibers having a fiber length of approximately 25mm or less, and most preferably of 2 to 5mm, in view of a fact that these second short fibers are primarily destined to be combined with said substrate and thereby to adequately reinforce holes and loose portions appearing in said substrate as a result of cross-stretching. Additionally, the second short fibers are preferably introduced onto the substrate with less uniform orientation of the fibers, for example, in the form of sheet or slurry. Selection of the second short fibers is not critical. In practice, any one or any combination of polyester, polyacryl, polyolefine, nylon, cellulosic(inclusive of rayon) fibers may be used depending on the particular application. It should be noted here that fibers having special cross-sections such as a flat cross-section are preferable since such special cross-sections suppress slippage of the second short fibers with respect to the substrate and facilitate the entanglement thereof. Specifically, woody pulp fibers or other cellulosic pulp fibers in the form of sheet or slurry are introduced onto the substrate as a monolayer or multilayers. After introduction of the second short fibers onto the substrate,

this lamellar material is subjected again to the fiber entanglement treatment by water jets so as to combine two components. Preferable sheet-like pulp fibers include tissue paper and so-called pulp sheet usually used for paper making, which are of a desired basic weight and can be easily loosened by the water jets.

Particularly when the composite nonwoven fabric of the present invention is prepared as material of the surgical operating room garments such as gown, drape, hood and bed sheets, it is preferable to introduce the pulp fibers and the synthetic fibers onto the substrate in previously mixed condition or so that thses two types of fibers may be mixed together on said substrate in order to achieve good feeling and softness rather than to introduce said pulp fibers alone as the second short fibers onto said substrate. The most preferable composition of such nonwoven fabric consists of the substrate having a basic weight at least of $20g/m^2$ and the second short fibers comprising 30 to 90% by weight of the synthetic fibers such as polyester fibers having a fiber length of 3 to 5mm and a fineness of 0.1 to 3d and 10 to 70% by weight of the pulp fibers so that the nonwoven fabric as whole has a basic weight of 25 to $100g/m^2$. Such nonwoven fabric is preferable for the above-mentioned application such as the operating room gown also in that such nonwoven fabric has high water resistance, fluid barrier property and

breathability.

To improve the initial tensile strengths both in the machine direction(MD) and the cross direction(CD) and to provide the nonwoven fabric being prepared with a high dimensional stability, a weight ratio of the second short fibers with respect to the first staple fibers is preferably at least 1/4. For example, it is preferable to combine the cross-stretched nonwoven fabric having a basic weight of $40g/m^2$ with the sheet-like pulp fibers having a basic weight of at least $10g/m^2$.

For the fiber entanglement treatment by use of the secondary water jets, the fiber entanglement method of prior art, for example, as disclosed by U.S. Patent No. 3,485,706 may be used.

As a result of the primary water jet treatment for the fiber eatanglement effect, a plurality of continuous lines (jet traces) along which the fibers entangle together with relatively high entanglement degree are formed in the nonwoven fabric, said lines or traces are spaced from one another at a distance corresponding to that between the orifice arrays adapted to jet high pressure fluid. The spacing between said jet traces is enlarged as a result of the subsequent cross-stretching treatment to form the starting nonwoven fabric and the previously mentioned holes and loose portions appear predominately in the region

defined between each pair of adjacent jet traces. Therefore, to combine the second short fibers with the starting nonwoven fabric and thereby to fill said region with said second short fibers, the secondary water jets for the fiber entanglement treatment are preferably supplied at a high pressure from the orifice arrays spaced from one another at a shorter distance than that between each pair of adjacent jet traces formed on the cross-stretched nonwoven fabric as the starting nonwoven fabric.

Specifically, the fiber entanglement treatment by use of the secondary water jets is carried out as follows: sheet-like or slurry-like second short fibers are introduced onto the cross-stretched nonwoven fabric substrate, then water jets are supplied from above said second short fibers at a velocity of 40m/sec or higher and under a pressure of at least 10kg/cm^2 on a support comprising a netlike support of less than 60 meshes or a perforated plate having an opening ratio of 2.5 to 50%. This lamellar fibrous web is drained off by suction means arranged under said plate if desired. The suction drainage is every effective to avoid an undesirable phenomenon that the second short fibers float in stagnant water on the substrate and the filling efficiency is thereby deteriorated. In nozzle means arranged transversely of the lamellar material consisting of the substrate and the second short fibers, it is preferable

to use orifices each being of 0.05 to 0.25mm diameter and arranged at a pitch less than 1mm, preferably at a pitch of 0.25 to 0.7mm. Such diameter and pitch are preferable in consideration of an effect with which the substrate is filled with the second short fibers.

The composite nonwoven fabric thus prepared in accordance with the present invention gets now predominately its region defined between each pair of adjacent jet filled and entangled with the second short fibers so that said holes and loose portions are effectively reinforced. With a consequence, the traces of jets are formed on a layer predominately comprising the second short fibers at spacings narrower than the spacings at which the traces of jets are formed on a layer predominately comprising the first staple fibers of this composite nonwoven fabric. The composite nonwoven fabric constructed in accordance with the present invention exhibits a steeply rising S-curve in the diagram showing a correlation between the stretch and the tensile strength. This steep S-curve appears not only MD direction but also in CD direction. As will be apparent from the diagram, the composite nonwoven fabric has a property required for the dimensional stability, i.e., the initial tensile strength is sufficiently high to suppress any significant stretch. It should be understood that this composite nonwoven fabric may be treated with well known

repellent and subjected to well known softening treatment if desired.

Advantages of the present invention will be further apparent from Examples as described in connection with corresponding Comparisons.

Comparison 1

A card web comprising 100% of 1.4d X 44mm polyester fibers was subjected to the primary entanglement treatment by columnar water jets at a pressure of 50kg/cm^2 to obtain the starting nonwoven fabric weighing 40g/m^2. After cross-stretching by approximately 30%, this nonwoven fabric was subjected to the secondary fiber entanglement treatment by fluid at a pressure of 50kg/cm^2. The primary fiber entanglement treatment used the orifices each having a diameter of 0.13mm and arranged at a pitch of 1mm, and the secondary fiber entanglement treatment used the orifices each having a diameter of 0.92mm and arranged at a pitch of 0.5mm.

Example 1

Two paper-like pulp fiber sheets each weighing 21g/m^2 one put on another were placed on the starting nonwoven fabric weighing 40g/m^2 obtained in the same manner as in Example 1 and then cross-stretched by approximately 30%, and

then columnar water jets at a pressure of $50kg/cm^2$ as in Comparison 1 were supplied from above said pulp fiber sheets for the secondary fiber entanglement treatment. The orifice diameter and the orifice pitch for the primary and secondary fiber entanglement treatment were respectively the same as in Comparison 1.

Stretch/tensile strength correlations both in MD and CD were determined for the nonwoven fabric obtained in Comparison 1 and Example 1, respectively, and plotted in Figs. 1 and 2 respectively by solid and broken lines.

In Example 1 and Comparison 1, the number of st[illegible]s for the secondary fiber entanglement treatment, i.e., amount of fluid energy being supplied was increased and properties of the nonwoven fabric thus obtained were determined. Determination indicated no difference in the correlation of stretch/tensile strength.

Example 2

A card web comprising 100% of 1.4d X 44mm polyester fibers was subjected to the primary fiber entanglement treatment by columnar water jets at a pressure of $50kg/cm^2$ to obtain nonwoven fabric weighing $52g/m^2$. After cross-stretching by approximately 30%, a paper-like pulp fiber sheet weighing $20g/m^2$ was introduced onto this nonwoven fabric and subjected to the secondary fiber entanglement

treatment by columnar water jets at a pressure of $50kg/cm^2$ to obtain composite a nonwoven fabric weighing approximately $60g/m^2$. Orifice diameter and orifice pitch used respectively in the primary and secondary fiber entanglement treatment were the same as in Example 1.

Comparison 2

A card web comprising 100% of 1.4d X 44mm polyester fibers was subjected to the fiber entanglement treatment by columnar water jets at a pressure of $50kg/cm^2$ to obtain a nonwoven fabric weighing $80g/m^2$. After cross-stretching by approximately 30%, this nonwoven fabric was subjected again to the fiber entanglement treatment by columnar water jets at a pressure of $50kg/cm^2$ to obtain a nonwoven fabric weighing approximately $60g/m^2$.

Stretch/tensile strength correlations both in MD and CD were determined for the nonwoven fabric obtained in Example 2 and Comparison 2, respectively, and plotted in Table 1.

Table 2 indicates CD/MD dimensional changes (reduction ratio) occurring due to MD/CD tension as weight ratio of the first and second fibers changes. For determination of the dimensional changes, each nonwoven fabric sample of a standard dimension (200 X 50mm) was MD-stretched under a load of 2kg and CD-stretched under a load of 250g, and the dimension reduction ratios both in CD and MD were determined.

TABLE 1

	MD STRENGTH (g/inch)					CD STRENGTH (g/inch)				
STRETCH(%)	2	5	10	15	*MAX	5	10	25	50	*MAX
EXAMPLE 2	259	909	2351	4314	11615	191	377	774	2061	3305
COMPARISON 2	113	194	345	533	8830	71	126	284	1040	3473

*MAX represents a strength at a moment of breakage.

TABLE 2

RATIO BY WEIGHT		DIMENSIONAL REDUCTION(%)	
1st fibers	2nd fibers	I	II
100	133	0	0
100	31	6	0
100	27	6	0
100	25	18	2
100	10	54	39
100	0	58	48

I: Cross-direction dimensional reduction under machine-direction tension.

II: Machine-direction dimensional reduction under cross-direction tension.

CLAIMS

1. A composite nonwoven fabric comprising a nonwoven fabric substrate composed of first staple fibers and second short fibers entangled on and in said nonwoven fabric substrate under action of fluid, characterized by that said substrate comprising a fiber-entangled nonwoven fabric stretched in cross direction by 20 to 200% and that traces of fluid jets are formed on a layer of said fabric comprising predominantly the second short fibers, which are more closely spaced from one another than traces of the fluid jets formed on a layer of said fabric comprising predominantly the first staple fibers.

2. The composite nonwoven fabric according to Claim 1, wherein a ratio by weight of said second short fibers with respect to the first staple fibers is at least 1/4.

3. The composite nonwoven fabric according to Claim 1, wherein said first staple fiber has a fiber length of 20 to 130mm and a fineness of 0.7 to 6d.

4. The composite nonwoven fabric according to Claim 1, wherein said second short fiber has a fiber length less than 25mm and a fineness less than 3d.

5. The composite nonwoven fabric according to Claim 1, wherein said first staple fibers are polyester fibers.

6. The composite nonwoven fabric according to Claim 1, wherein said second short fibers comprise any one or a

combination of pulp fibers and synthetic fibers.

7. An operating room gown or drape prepared from the composite nonwoven fabric according to Claim 1, wherein said second short fibers comprise at least pulp fibers.

8. The operating room gown or drape prepared from the composite nonwoven fabric according to Claim 7, wherein said second short fibers comprise a mixture of 10 to 70% by weight of pulp fibers and 30 to 90% by weight of synthetic fibers having a fineness of 0.1 to 3d.

9. The operating room gown or drape prepared from the composite nonwoven fabric according to Claim 7, wherein the nonwoven fabric substrate comprising said first staple fibers has a basic weight of $20g/m^2$ and a lamellar material including said second short fibers has a basic weight of 25 to $100g/m^2$.

10. A process for preparing composite nonwoven fabrics comprising:

a first step of subjecting a fibrous web comprising first staple fibers to a water jet treatment on a support to form a fiber-entangled nonwoven fabric substrate;

a second step of cross-stretching said substrate by 20 to 200%;

a third step of introducing second short fibers in the form of a sheet or slurry onto said substrate which has been cross-stretched;

a fourth step of subjecting a lamellar material thus comprising said cross-stretched substrate and said second short fibers placed on said substrate to a water jet treatment at a velocity of 40m/sec or higher and under a pressure of at least $10kg/cm^2$ onto said second short fibers from above, the water jets being more closely spaced from one another than traces of the jets which have been formed on said stretched substrate at said second step, on a support comprising a netlike support or perforated plate having an opening ratio of 2.5 to 50%, so as to entangle said second short fibers among the fibers of said cross-stretched substrate and thereby to fill interstices of said substrate fibers.

11. The process according to Claim 10, wherein orifices used at said fourth step are arranged at more close pitch than the pitch of jet traces formed on said cross-stretched substrate, preferably at a pitch less than 1mm, and each of said orifices has a diameter of 0.05 to 0.25mm.